Air Force SBIR **Impact**

Dynamic Polymer Composite Connectors Innovate Stress Technology

Company:
The Technology Partnership

Location:
Grosse Ile, Michigan

Employees:
8

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Air Force Requirements:

The Air Force is always looking for material technologies that will enhance structural capabilities while reducing weight and cost. For liquid rocket engines a large portion of the non-fuel weight is tied up in the heavy, expensive alloy piping. Converting this piping to polymer matrix composites (PMC) would save weight and cost but the joining of PMCs has always been the major hurdle. Dynamic polymer composite (DPC) connectors would eliminate bolted flanges, eliminate expensive bellows, connect dissimilar materials and enable protective linings.

SBIR Technology:

The Technology Partnership's SBIR Phase I and II contracts demonstrated and developed an effective DPC connector for an all-composite airframe. When designed into an original airframe, DPC connectors allow rapid replacement of major airframe components and assemblies. DPCs not only resist force, they generate force due to the release of stored pre-stress energy. These connectors work like a portable injection molding machine. When heated, DPC connectors force hot, pliable polymer matrix into every crevice and pore of a joint and then clamp that joint with their remaining reserve of hoop tension as they cool. The result is a quick, full-moment connection without joint preparation, hand layup, contact with adhesives or autoclaving. Launch vehicles are the immediate candidates for the technology. The weight savings amount to about five percent of the rocket engine which translate into about two million dollars cost saved per launch. The present worldwide market for composite rocket engine lines and ducts is estimated at $1.6 billion.

Other areas where DPC technology is expected to make a significant impact for both the Air Force and the commercial market include:

Cryogenic Tanks: DPC connectors simplify tank fabrication and cost because they eliminate the obligatory flanges of current tank design. This has positive impact on aerospace vehicle tanks as well as future compressed-gas fueled trucks and cars.

Composite Cryopipe: It was found that pre-stress of a cured composite pipe would prevent cracking of a composite matrix that has been exposed to extreme low temperatures by maintaining compressive stress on the member. Alloy ducts, lines, tees, elbows, and transitions can be fabricated and tested as individual cryopipe components and assembled with DPC connectors.

Expansion Bellows: The most expensive component of rocket engine piping is the alloy expansion bellows. A bellows is needed on every pipe run due to temperature, vibration, impact and movement. During Phase II testing it was found that DPC connectors

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can be designed to allow longitudinal movement while maintaining joint integrity. This application is now being funded by BMDO and should save over $1 million per launch vehicle for some 50 launch vehicles per year.

Thermal Buss: The electronic components for satellites create substantial cooling loads. The structures that radiate and dissipate this heat must be light but survive launch loadings, reconfiguration loadings and radiation exposure. DPC connectors reduce the cost and complexity of composite thermal buss. About 50 launches this year will require advanced cooling worth about $4 million in DPC connectors.

Electrical Cable: The joining of electrical cable carrying high electrical loads is difficult to achieve. Problems are found with connectors in such widely divergent areas as the electrical conductors within a jet engine and electrical power transmission lines. The requirements are high clamping force and an ability to conform to the surfaces of the cable to be joined. Transmission Line News estimates the addition of 5000 miles of new line each year yielding a $25 million a year connector market.

Commercial Aircraft: The limitation on composite use in commercial aircraft has been that composites have not been capable of matching the component design and replacement of aluminum structures on which the industry is based. For a commercial aircraft with a polymer composite structure, DPC connectors allow this component replacement even in the field. DPC connectors make possible an integrated aircraft where structure and service lines are integrated.

Commercial Composite Piping: The Technology Partnership has partnered with Ameron, a large composite pipe producer for use in process plants, oil and gas production fields and piping for hazardous materials. Ameron estimates that the current yearly potential market for DPC connectors is $25 million. However, DPC connectors increase the market reach for standard FRP pipe by $100 million a year. Testing to conform to industry specifications is underway.

Company Impact:

The AF SBIR funding helped turn a one-person small business into a recognized technology supplier to the satellite launch vehicle community. The Technology Partnership is developing an expanding patent portfolio related to PMC systems for rocket engine systems providing the company a strong foothold in a billion dollar market. Its technology development success has also resulted in additional funding from the Ballistic Missile Defense Office (BMDO), and the attention of the launch vehicle community. In addition, the company has joined in a strategic alliance with the dominate global supplier of PMC pipe to the oil and gas industry. This alliance will serve to transfer the technology to the commercial infrastructure.

Company Quote:

"The AF SBIR program support for Dynamic Polymer Composites had a major impact upon our company. The Phase I & II funding was important. But more important was the validation that we received from our contacts with Air Force technical personnel. They recognized that a stress-control technology had the potential to shift the balance in favor of polymer composites in a large number of applications that were limited by current joining techniques. This technology's performance enhancements and the forecasted savings in fabrication and assembly can all be traced to that recognition."

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SBIR

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